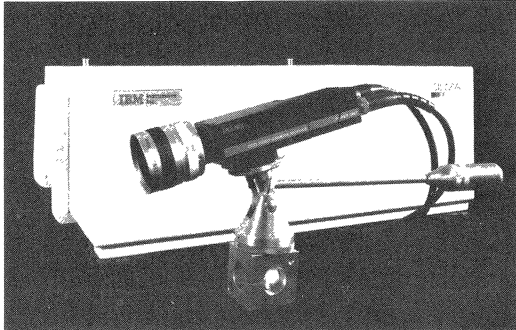
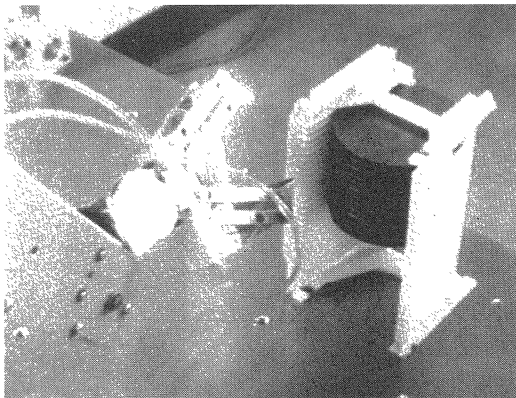


VISICAM<sup>TM</sup>

SILMA  
A VISION OF THE FUTURE



SILMA 9000™ VISION PROCESSOR



VIDEO IMAGE OF CASSETTE IN UNKNOWN POSITION AND ORIENTATION

## **VISICAM™**

VISICAM is a Computer Aided Engineering workstation for generating 3-D vision programs for inspection and robotic applications. The vision programs run on the SILMA 9000™ vision processor.

The unrestricted capability of automatically recognizing 3-D objects in TV images opens a vast new field of applications for computer vision. SILMA is the first company to introduce products with this capability.

Together with ROBOCAM™, a robotic simulation and programming environment, VISICAM is part of SILMA's SILCAM™, the first fully integrated system for 3-D modeling, simulation, computer vision and robotics.

## **FULL 3-D VISION CAPABILITIES**

Vision programs generated by VISICAM will identify and locate 3-D objects in any position and 3-D orientation from ordinary gray-level TV images.

VISICAM programs will even recognize complex 3-D parts which are in contact, overlapping, or partially occluded by other objects.

Typical recognition times range from half a second for well structured applications, to several seconds for unstructured situations (jumbled parts in a cluttered background, for instance).

## **MONO OR STEREO VISION**

Because of the true 3-D nature of SILCAM vision programs, only one CCD or Vidicon camera is required for most 3-D inspection or robotic applications. For the most demanding applications, a second camera can be used in a stereo mode to achieve higher precision measurements.

## **FREEDOM FROM ARTIFICIAL RESTRICTIONS**

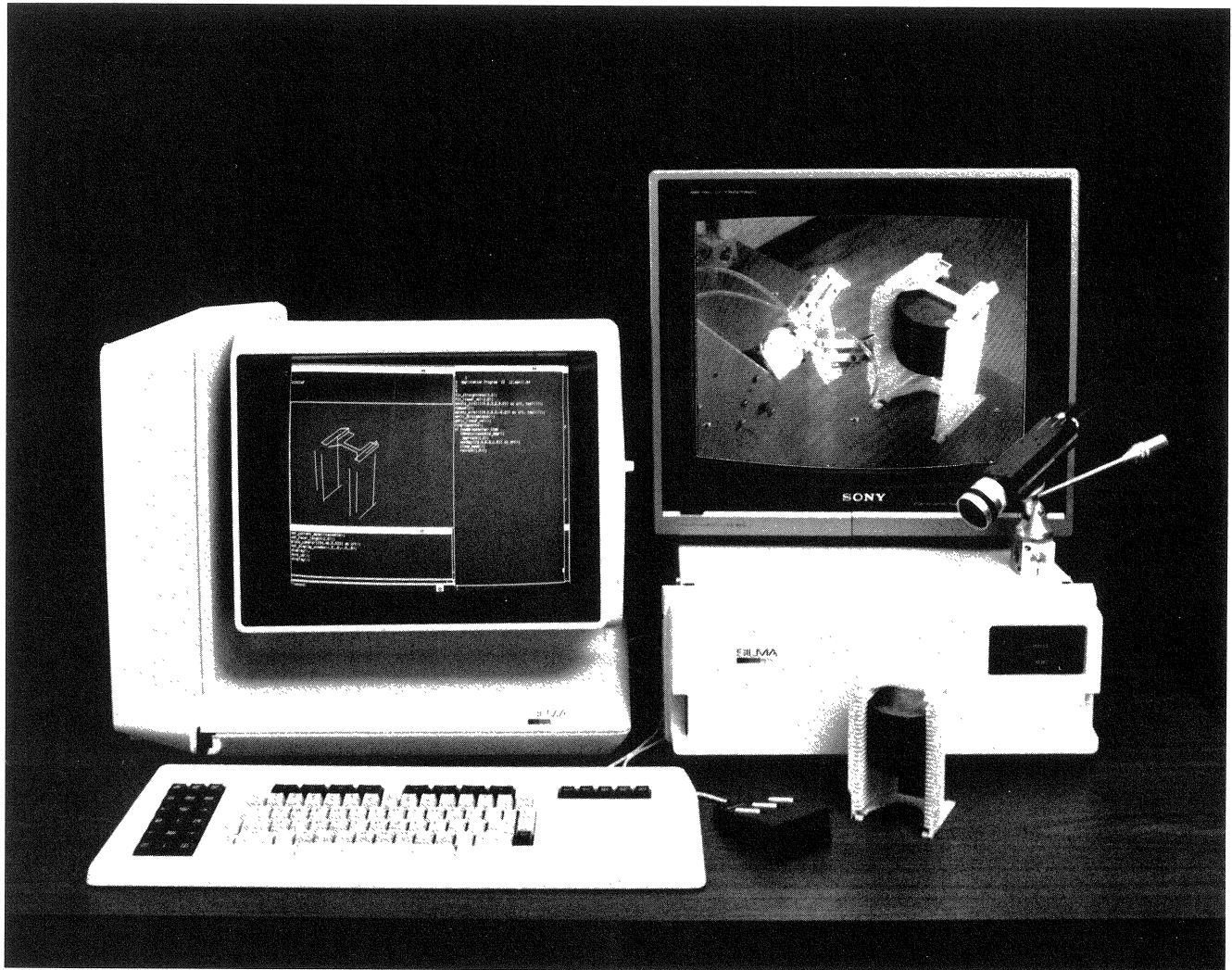
With VISICAM programs there are no restrictions on the position of the camera relative to the objects, and no special lighting or background conditions required. VISICAM programs rely on an edge detection strategy which is far more robust than the thresholding techniques used by most available vision systems.

## **3-D VISION FOR LESS**

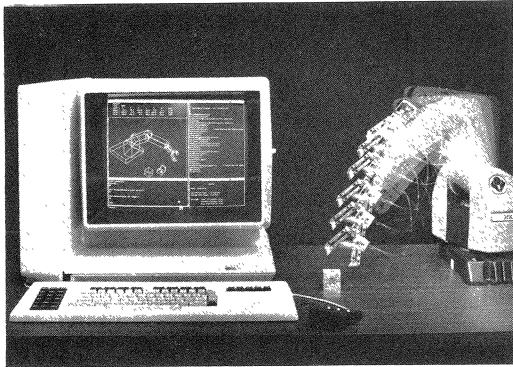
VISICAM is the workstation used for generating vision application programs. SILMA also provides a target system, the SILMA 9000 vision processor, for running these applications on the factory floor. Downloading of programs from VISICAM to the SILMA 9000 is fully automatic.

The SILMA 9000 processor sells well below the cost of most commercially available 2-D systems. And that's for hardware and application software!

Together these two systems deliver the best of both worlds: sophisticated off-line development tools and a cost effective on-line vision system.



TYPICAL VISICAM™ CONFIGURATION: DN 300  
GRAPHICS WORKSTATION, DSP 80 VISION  
PROCESSOR, CCD CAMERA AND COLOR MONITOR



ROBOCAM™

- Fast high resolution image acquisition and display (30 frames per second). Choice of image and pixel resolution (512 x 512 or 256 x 256; 64 or 256 gray levels)
- SILIMAGE™, a powerful utility package providing fully interactive facilities for acquiring, displaying, manipulating and analyzing images throughout the network
- Large library of application software (Electrical/Electronic CAD, Mechanical CAD, Design Analysis, Computer Aided Software Engineering and Text Processing) available from third parties

## THE VISICAM ENVIRONMENT

### VISICAM™ HARDWARE

Based on the Apollo DOMAIN family of computers.

- Minimum configurations are: DN 300 or 320 (1.5 Mb) and DSP 80 or DSP 160 (1.0 Mb) // DN 460 or 660 (2.0 Mb) with PNA option
- Maximum configuration: Any DOMAIN network including the minimum configuration.

### TARGET HARDWARE

The SILMA 9000 vision processor is a modified version of the IBM 9000 computer which offers 32-bit processing power, reliability, and excellent communication capabilities (three RS232C interfaces, one parallel interface and IEEE 488 bus interface). The SILMA 9000 can run in various configurations including stand-alone, connected to a process control computer or an industrial robot controller.

### VISICAM™ SOFTWARE

#### SILMODEL™ Interactive 3-D modeling system.

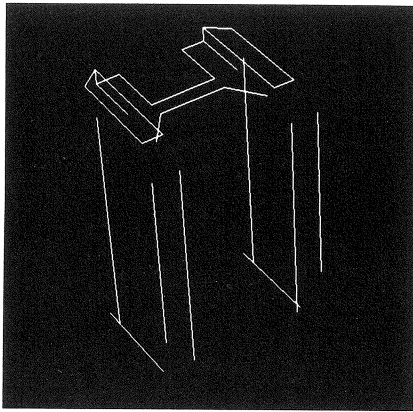
SILMODEL is common to ROBOCAM and VISICAM. The same 3-D model descriptions constructed by SILMODEL are used for vision programs (in VISE), robotic programs (in RISE™, SILMA's robot programming language), and for robotic workcell simulation.

SILMODEL makes use of simple wire frame models in which only those object edges needed for the recognition or inspection task are described. This allows the modeling task to be completed in just a few hours for most applications. An interface between SILMODEL and selected user CAD data bases will in some instances cut the modeling time down further.

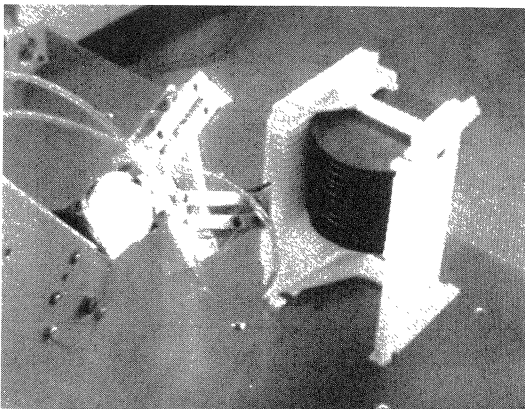
#### SILGEN™ Automatic generator of vision programs.

3-D models of objects are passed to SILGEN which automatically generates 3-D recognition programs for these objects. For most applications, SILGEN is fully automated, so that no user programming is required at all for finding objects in images.

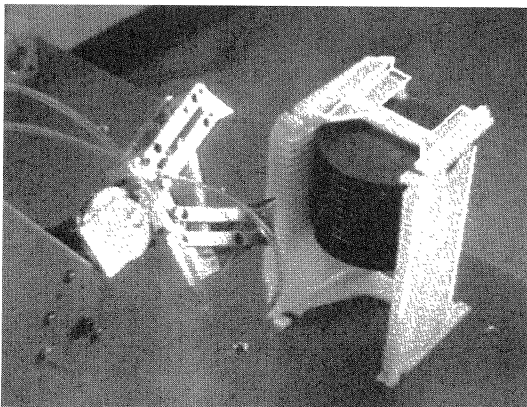




AN EXAMPLE OF A 3D MODEL: A CASSETTE OF SILICON WAFERS AS MODELED IN SILMODEL™



EDGES USED IN THE MATCHING PROCESS



DISPLAY OF A SUCCESSFUL MATCH: THE MODEL OF THE CASSETTE OVERDRAWN ON THE PICTURE OF THE ACTUAL CASSETTE.

### 3-D VISION PROGRAMS ARE AUTOMATICALLY GENERATED

Unlike other vision systems now available, VISICAM automatically generates 3-D vision programs to recognize individual parts. In order to produce a recognition program, VISICAM normally only needs a 3-D model of the part to be recognized. Such 3-D models are easily built using the SILMODEL™ modeling system supplied with VISICAM. Alternatively, they can be taken from an existing CAD data base. So once a part has been modeled, instances of the part can be automatically recognized and located in TV images.

### A POWERFUL LANGUAGE FOR VISION PROGRAMMING

Full application programs for inspection or robotics applications are written in VISE™, an interactive language developed by SILMA specifically for vision applications. VISE makes application vision programs extremely easy to write using high level commands, such as FIND, CHECK, MEASURE, COMPARE.

VISE is intimately integrated with SILMODEL, the 3-D modeling system, so models of parts and their sub-parts can simply be referred to by name in a VISE program. VISE automatically translates these high level commands into their intricate numerical representations. Resulting application programs are highly readable.

Although VISE is quite easy to learn and use, it is embedded in an extremely general and powerful language for the manipulation of 3-D spatial information. Even the most advanced programmers and researchers will never feel confined in the VISICAM environment.

### FULL COMPATIBILITY WITH SILMA'S ROBOCAM

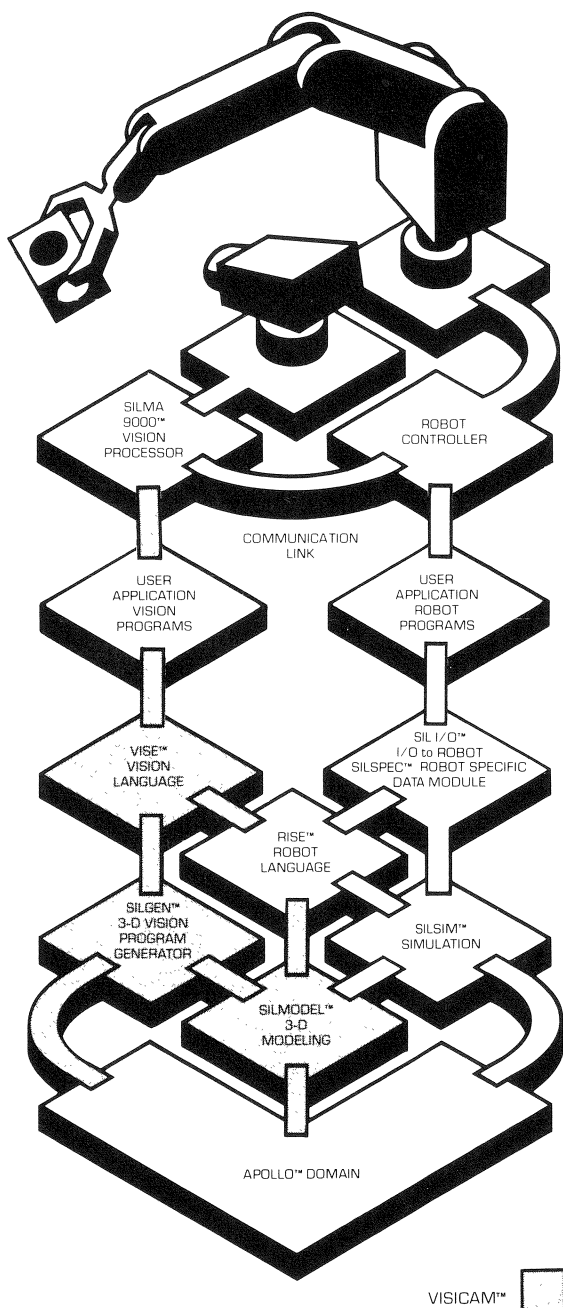
ROBOCAM, SILMA's robot programming and simulation system may be added to VISICAM to form SILCAM, a fully integrated environment for 3-D modeling, simulation, vision and robotics.

Robot programs developed on ROBOCAM use VISE routines freely for identifying and locating objects. The same 3-D models of parts used to generate vision programs on VISICAM are used in ROBOCAM for robotic programming and graphic simulation of the robot workcell.

### STATE OF THE ART DEVELOPMENT ENVIRONMENT

VISICAM offers hardware and software productivity tools for the most demanding programmers:

- Dedicated 32 bit high performance desktop mainframe per user
- High resolution, bit-mapped graphics (1024 by 800 pixels)
- High performance 12 megabit per second local-area-network with networkwide virtual operating system
- Expandability with no loss of performance as you add users
- User-friendly interface with graphics, mouse, screen windows, user definable keys, and help commands



## **VISE™ A full programming language with special features for vision.**

Application programs for inspection applications are written in VISE.

VISE programs call the FIND subroutines automatically generated by SILGEN to identify and locate objects in the image. Other VISE primitives allow a variety of operations such as:

CHECK: check for the presence or absence of a particular feature.

MEASURE: measure 3-D distances between parts or between features on parts.

COMPARE: compare a feature dimension with nominal dimensions and defined tolerance bounds.

VISE programs are fully symbolic. VISE programs refer to all objects, locations, features, etc., by the names given to them in the modeling system and not by their coordinates. Typical VISE programs need contain no geometric or numerical coding at all, but only sequences of FIND, CHECK, MEASURE and COMPARE operations applied to named objects and features.

VISE is a full programming language offering strong typing, generic operators (e.g. the single operator "+" may be applied to integers, reals, vectors, etc.), automatic translation between alternative geometric representations of types (cartesian to cylindrical to spherical coordinates, etc.) high performance numerical capabilities, and a convenient PASCAL-like syntax.

Facilities for merging VISE programs into existing PASCAL applications are provided: VISE programs can call PASCAL routines and vice versa. Further, VISE programs can be compiled into PASCAL code.

## **SILIMAGE™ Utility package for acquisition and display of images.**

SILIMAGE provides simple interactive commands for image acquisition, display, manipulation and analysis throughout the network. The image acquisition and display hardware can be accessed easily from any node in the network.

\*DOMAIN is a trademark of Apollo Computer Inc.

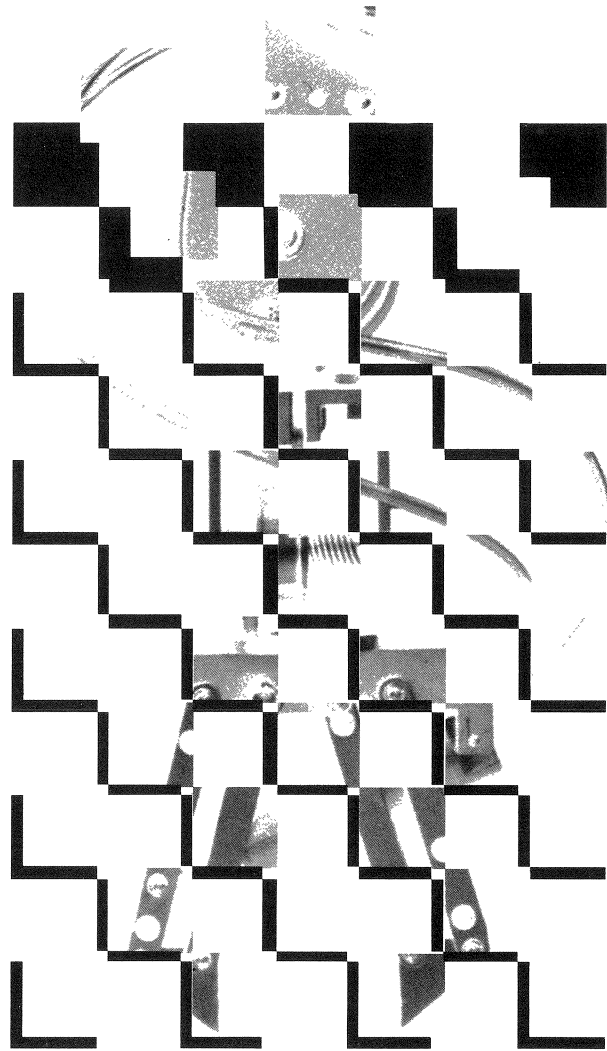
\*IBM 9000 is a trademark of IBM Instruments Inc.

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# SILMA

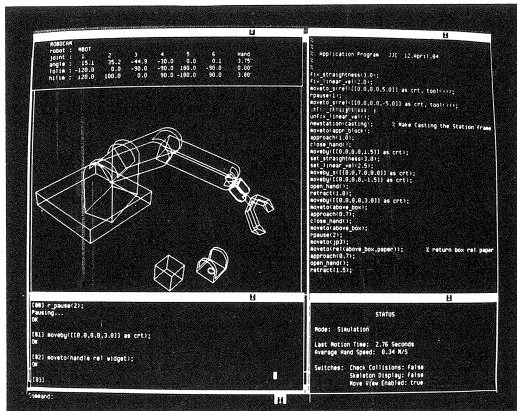


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PALO ALTO, CA 94303  
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ROBOCAM™

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APPLICATION PROGRAM IN RISE™

```
%
%
% Application Program   JJC 12.April.84
%
%
fix_straightness(3.0);
fix_linear_vel(2.0);
moveto_s(rel([0.0,0.0,5.0]) as crt, tool());
rpause(1);
unfix_linear_vel();
newstation(casting);      % Make Casting the Station
moveto(appr_block);
approach(1.0);
close_hand();
moveby([0.0,0.0,1.5]) as crt);
set_straightness(3.0);
set_linear_vel(2.5);
moveby([0.0,0.0,-1.5]) as crt);
open_hand();
retract(1.0);
moveby([0.0,0.0,3.0]) as crt);
moveto(above_box);
approach(0.7);
close_hand();
moveto(above_box);
rpause(2);
moveto(jp3);
moveto(rel(above_box,paper));      % return box rel
approach(0.7);
open_hand();
retract(1.5);
```

HARD COPY OF AN APPLICATION PROGRAM IN RISE™

## ROBOCAM™

ROBOCAM is a Computer Aided Engineering workstation for on-line or off-line programming of industrial robots, and for simulation of robots and their workcells.

Together with VISICAM™, a 3-D vision programming environment for inspection and robotic applications, ROBOCAM is part of SILMA's SILCAM™, the first fully integrated system for 3-D modeling, simulation, computer vision and robotics.

## AN EASY, COST EFFECTIVE WAY TO PROGRAM ROBOTS

ROBOCAM was designed to make programming robots easier, make simulating their workcells affordable, and to reduce the overall installation costs of robots.

In the ROBOCAM environment, various possible layouts for a robotic workcell are easily described using SILMODEL™, the 3-D modeling system.

Robot commands are entered interactively and can be viewed in simulation on the workstation screen for verification and testing before being run by the manipulator itself. Users can quickly experiment with a variety of industrial robots in workcell simulation. Not only can the right robot for the job be quickly identified, but application code for the chosen robot can be developed and tested in simulation in the same environment.

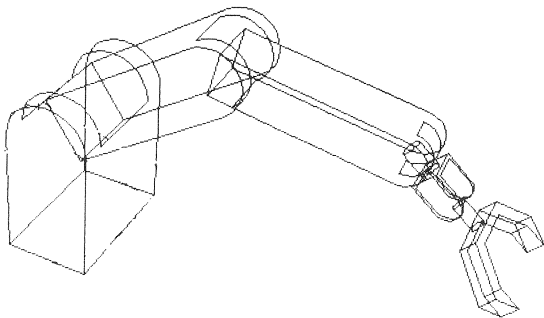
Arbitrarily complex application programs can be built up by iteration from simpler ones. Simulated moves of the robot on the screen provide instant feedback to the programmer after each change. A library of application programs can be assembled over time and stored for later retrieval. New application programs can be quickly generated from existing ones through cut- and-paste techniques.

Once a robot program has been written and debugged using the powerful tools provided with ROBOCAM, it is downloaded to the robot (when interface is available). Facilities are available to perform final calibration to the actual workcell parts and fixture placements. This final step is the only one that needs to be performed on the manufacturing site so installation time and disruptions in the production flow can be kept to a minimum.

## A POWERFUL ROBOT PROGRAMMING LANGUAGE

Robot programs are developed in RISE™, an arm-independent robot programming language developed by SILMA specifically for robot programming and simulation. It incorporates tools and time-saving features which can be found in no other robot programming language. (See RISE specifications following).

RISE makes robot sequences extremely easy to write using high level commands. RISE is intimately integrated with SILMODEL, the 3-D modeling system, so models of parts and their sub-parts can be simply referred to by name in a RISE program. RISE automatically translates these high level commands into their intricate numerical representations. Resulting application programs are highly readable since fixtures, tools, and parts



STATUS

Mode: Simulation

Last Motion Time: 2.76 Seconds  
Average Hand Speed: 0.34 M/S

Switches: Check Collisions: false  
Skeleton Display: false  
Move View Enabled: true

## THE ROBOCAM ENVIRONMENT

### ROBOCAM HARDWARE

Based on the Apollo DOMAIN<sup>®</sup> family of desktop mainframe computers, several configurations are available:

- Minimum configuration: Apollo DN300 or DN320 (1.5 Megabyte) or DN460 or DN660 (2.0 Megabyte).
- Maximum configuration: Any Apollo Domain network.

### ROBOCAM SOFTWARE

**SILMODEL<sup>™</sup>**, interactive 3-D modeling system.

SILMODEL is common to ROBOCAM and VISICAM. The same 3-D model descriptions are used for robotic programs (in RISE), vision application programs (in VISE<sup>™</sup>, SILMA's 3-D vision programming language), or fully integrated vision and manipulation programs.

Once they have been described in an interactive way using SILMODEL, parts and subparts of objects can from then on be referenced by their names only. SILMODEL makes use of wire frame models to describe the robot workcell, parts and tools, and the robot itself. Frames, grasping points and approach positions can easily be affixed to objects during the modeling session for later use in RISE programs. SILMODEL includes many built-in features to facilitate the modeling task. SILMODEL will also directly interface with selected user CAD data bases.

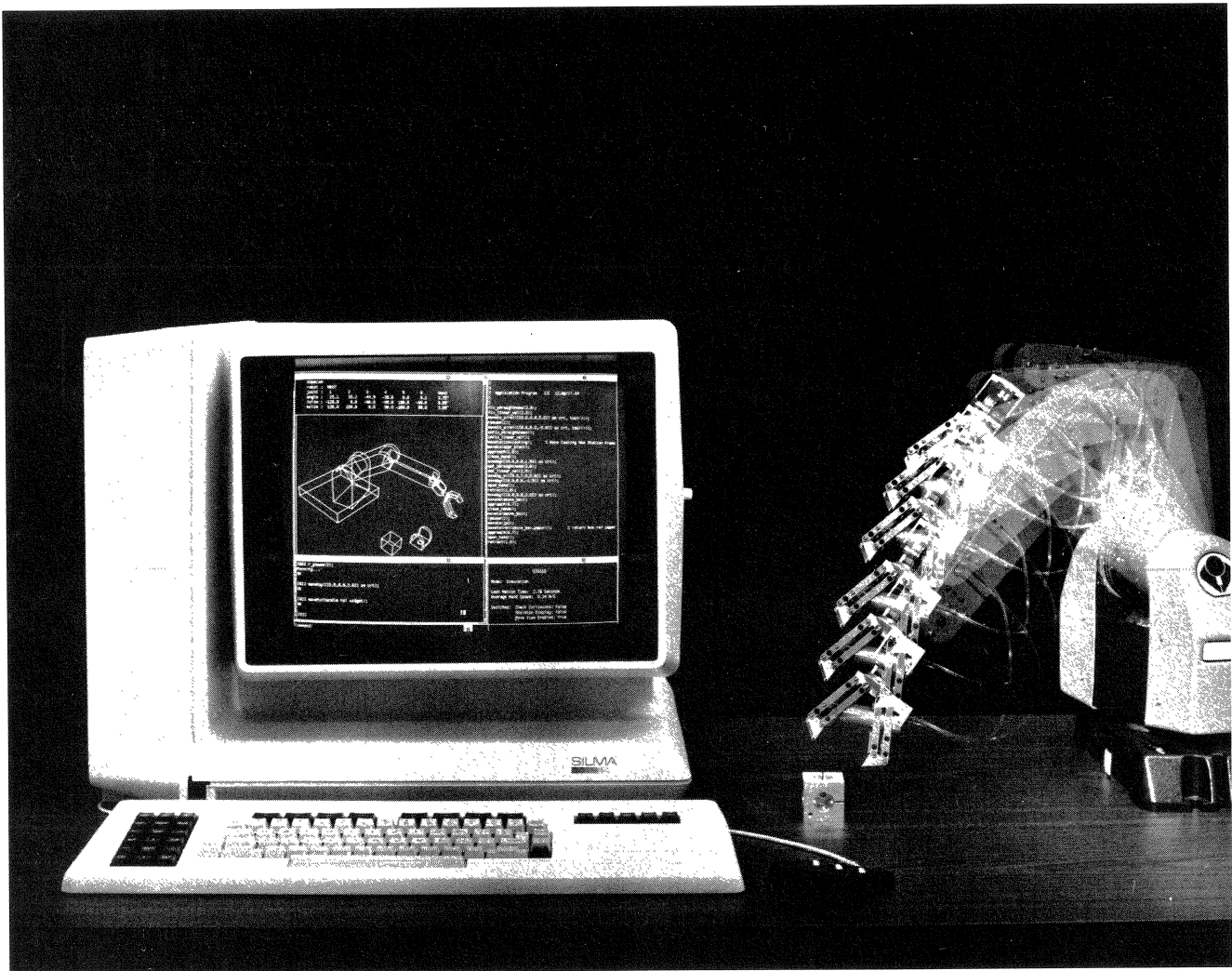
### RISE<sup>™</sup> A full programming language with special features for robot programming.

ROBOCAM application programs and simulation sequences are written in RISE. RISE provides some unique features which are extremely useful for writing manipulation programs:

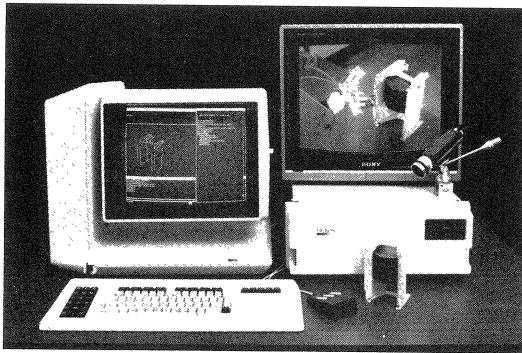
- Ability to use many different geometric representations of position and orientation
- General operators for translation and rotation which can be applied to any of these representations
- Ability to work in several pre-defined coordinate systems as well as in coordinate systems defined by the user
- Ability to quickly alternate between these coordinate systems, and in particular to execute the same paths with different end-effectors or tools
- Complete trajectory specifications based on via points and using default or user-supplied speeds or durations. Paths may be cartesian, straight lines or joint based
- Ability of users to extend the language with their own routines, including PASCAL routines.

RISE thus will accept very high level commands from users and automatically compute the corresponding low level numerical representations of operators and operands. RISE programs are fully symbolic. They will refer to all objects, locations, tools, fixtures, etc., by the names given to them in the modeling system and not by their coordinates or geometric descriptions. RISE programs need contain no geometric or numerical coding but only sequences of MOVETO, MOVEBY, etc., commands applied to named objects and features.

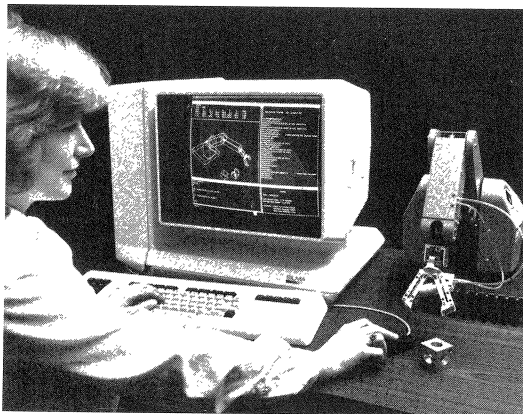
RISE is embedded in a full programming language also offering strong typing, generic operators (e.g. the single operator "+" may be applied to integers, reals, vectors, and other geometric entities), polymorphic functions, automatic translation between alternative geometric representations of types (cartesian to cylindrical to spherical coordinates, etc.), high performance numerical capabilities, and a convenient PASCAL-like syntax.



TYPICAL ROBOCAM™ CONFIGURATION: DN 300  
GRAPHICS WORKSTATION CONNECTED TO THE  
ROBOT CONTROLLER



VISICAM™ ENVIRONMENT: GRAPHICS WORKSTATION,  
VISION PROCESSOR, CCD CAMERA  
AND COLOR MONITOR



WORKING WITH ROBOCAM™

which the robot deals with are referenced by name, as in the statement "move to flange of motor-housing" which moves the robot tool to the "flange" subpart of the "motor-housing" part.

Although RISE is quite easy to learn and use, it is embedded in an extremely general and powerful language for the manipulation of 3-D spatial information. Even the most advanced programmers and researchers will never feel stifled in the ROBOCAM environment.

RISE programs can be interpreted or compiled. The availability of an interpreter speeds program development, while the compiler enables efficient execution of completed programs.

### **FULL COMPATIBILITY WITH SILMA'S VISICAM 3-D VISION SYSTEM**

When desired, VISICAM, SILMA's 3-D computer vision programming system may be added to ROBOCAM to form SILCAM, a fully integrated environment for 3-D modeling, simulation, vision and robotics.

VISICAM automatically generates application vision programs which recognize and locate 3-D objects in ordinary gray-level TV images. Vision programs run on the SILMA 9000 vision processor. With VISICAM, there are no restrictions on the position of the camera relative to the objects and no special lighting conditions required. The exact location of objects are determined quickly and robustly and made available for use in guiding the robot. The RISE "FIND" subroutines command the vision system and return 3-D position and orientation of recognized objects.

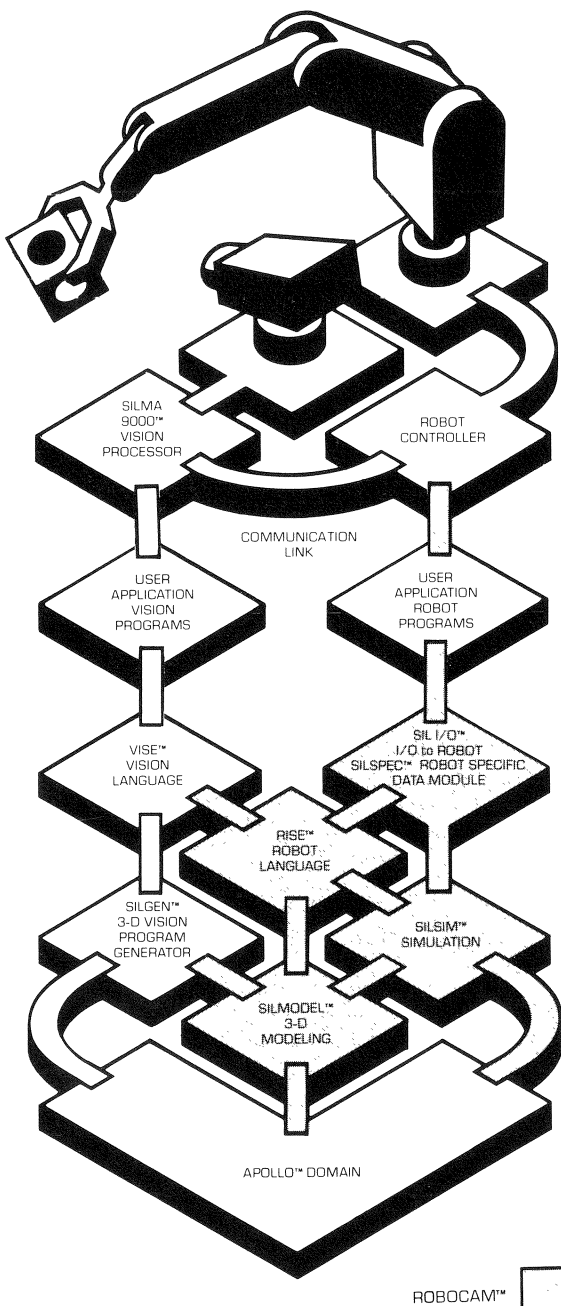
VISICAM is fully integrated with ROBOCAM. The same 3-D models of parts used in ROBOCAM simulations and RISE programs also serve to generate 3-D vision programs automatically on VISICAM.

### **STATE OF THE ART DEVELOPMENT ENVIRONMENT**

ROBOCAM offers hardware and software productivity tools for the most demanding programmers:

- Dedicated 32-bit high performance desktop mainframe per user
- High resolution, bit-mapped graphics (1024 by 800 pixels)
- High performance 12 megabit per second local-area-network with network-wide virtual operating system
- Expandability with no loss of performance as you add users
- User-friendly human interface with graphics, mouse, screen windows, user definable keys and help commands
- Large Library of application software (Electrical/Electronic CAD, Mechanical CAD, Design Analysis, Computer Aided Software Engineering and text processing) available from third parties.





#### **SILSIM™ software for robotic simulation.**

ROBOCAM runs on a workstation supporting powerful 3-D graphic simulations. Basic capabilities include the ability to quickly change viewing position and orientation, and projection of 3-D models. However SILSIM also provides many robot specific features such as display of current joint positions relative to maximum positions, real-time capability to do cycle time evaluation with various robots, and tools to aid in placing a robot optimally relative to workcell features.

#### **SILSPEC™ module of robot specific data.**

SILSPEC data for a specific manipulator includes kinematic and dynamic data, joint position, velocity, and acceleration limits, and other useful parameters. Once a robot specific SILSPEC is loaded in ROBOCAM, that robot may be programmed in RISE and simulated with SILSIM. Contact SILMA concerning the availability of a SILSPEC for a particular industrial manipulator.

#### **SIL I/O™ robot specific I/O package.**

SIL I/O provides the interface and format translation software which allows application programs developed in RISE to be downloaded to a particular robot controller. SIL I/O also provides the interface to that robot when ROBOCAM is used in an interactive on-line programming mode rather than in its off-line mode. Contact SILMA concerning the availability of a SIL I/O for a particular industrial manipulator.

#### **SILCAL™ workcell and robot calibration package.**

SILCAL allows the calibration of the modeled workcell to the actual workcell positions on the manufacturing site. SILCAL also includes routines to calibrate the robot arm itself using SILMA's 3-D vision system (requires additional hardware).

\*DOMAIN is a trademark of Apollo Computer Inc.

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# SILMA



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